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FUEL-CELL POWER GENERATING SYSTEM

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FUEL-CELL POWER GENERATING SYSTEM

[Nenryo denchi hatsuden shisutemu]

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Claims /1*

1. A fuel-cell power generating system characterized in that in a fuel-cell power generating system configured with a fuel-cell stack in which multiple battery cells each configured by providing a pair of electrodes comprising a fuel pole and an oxidant pole on either side of an electrolyte layer are layered together, and DC power is extracted from between the aforementioned electrodes utilizing an electrochemical reaction which takes place when a fuel is brought into contact with the aforementioned fuel pole and an oxidant, such as air, to the oxidant pole, a recycle line configured such that a portion of the electrode exhaust gas exhausted through an electrode exit exhaust gas pipe of at least the fuel pole or the oxidant pole is branched out and recycled into an electrode entrance pipe, and a recycle blower and a flow rate detector for

* [Numbers in right margin indicate pagination of the original text.]

detecting the gas flow rate are provided on said recycle line, a three-way valve is provided on the side of the spout of the aforementioned recycle blower, wherein one of its exits is connected to a line leading to the entrance of an electrode, and another exit is configured so as to be connected to a line leading to the intake side of the recycle blower, and a controller having a function to compare a flow rate signal from the aforementioned flow rate detector with a prescribed flow rate setting value signal is provided in order to regulate the valve opening levels of the aforementioned three-way valve according to the deviations.

2. A fuel-cell power generating system characterized in that in the fuel-cell power generating system described in Claim 1, a first valve is provided on the spout side of the aforementioned recycle blower, the exit side is connected to a line leading to the entrance of an electrode, a second valve is branched out from the spout side of the aforementioned recycle blower, a line configured so as to lead from the exit side to the intake side of the aforementioned recycle blower is provided, and a controller having a function to compare a flow rate signal from the aforementioned flow rate detector with a prescribed flow rate setting value signal is provided in order to regulate the respective opening levels of the first and the second valves according to the deviations.

Detailed explanation of the invention

Technical field of the invention

The present invention pertains to a fuel-cell power generating system. In particular, it pertains to a fuel-cell power generating system in which flow rate of battery exhaust gas in a recycle line can be regulated.

Technical background of the invention and problems

In recent years, a fuel-cell power generating system has become known as a system by /2
which the energy a fuel has is converted directly into electric energy. In said fuel-cell power generating system, usually, the fuel-cell is configured by placing a pair of porous electrodes on either side of an electrolyte, a fuel, such as hydrogen, is brought into contact with the back surface of one of the electrodes, and an oxidant, such as oxygen, is brought into contact with the back surface of the other electrode in order to extract electric energy from the aforementioned electrodes utilizing an electrochemical reaction taking place then; whereby, the electric energy can be extracted highly efficiently as long as the aforementioned fuel and the oxidant are supplied.

Figure 4 shows the basic configuration of a typical fuel-cell power generating system of this type. In the figure, fuel 1 is a fossil fuel, such as a natural gas or a carbon dioxide gas, and steam from steam feeder 2 is introduced into reforming contact [sic; catalyst] tube 6 provided within fuel reformer 5 while they are controlled using fuel control valve 3 and steam control valve

4 in such a manner that the mixture molar ratio of the steam and the carbon becomes 3 to 5. Here, the steam and fuel 1 are heated to 500-600°C for a reforming reaction to take place, and they are then put through transformer 7 to become a reformed fuel with a high hydrogen content. After said reformed fuel with a high hydrogen content is sent to fuel gas steam separator 8 so as to remove the reformed excessive steam, it is sent to auxiliary burner 9 and fuel pole 11A of fuel-cell 11 while their flow rates are regulated using auxiliary burner fuel control valve 10 and reformed fuel control valve 12, respectively.

The reformed fuel flow into fuel pole 11A of fuel-cell 11 is subjected to a catalytic reaction with the air flow into oxidant pole 11B. A portion of the fuel is consumed as a result, and electric energy and reaction-generated water are obtained. While fuel exhaust gas from fuel pole 11A which contains a portion of the reaction-generated water generated in said fuel-cell 11 is sent as fuel to main burner 13 of aforementioned fuel reformer 5, it is sent through steam separator 16 in order to recover the moisture in the gas along the path.

Then, the fuel exhaust gas sent to main burner 13 is burned in fuel reformer 5 and exhausted as high-temperature exhaust gas 17 after it heats up reforming catalyst tube 6. Furthermore, after it is mixed with the air exhaust gas sent from oxidant pole 11B of fuel-cell 11, it is sent to mixer 18 and used as a part of the energy for driving turbo compressor 19. On the other hand, the reformed fuel sent to auxiliary burner 9 is burned in auxiliary burner 9, and the resulting burned gas goes through mixer 18 to drive turbine 19A of turbo compressor 19. On the other hand, air blown from compressor 19B driven as it is linked to aforementioned turbine 19A is sent to auxiliary burner 9 and main burner 13 while the air-fuel ratio is regulated using auxiliary burner air control valve 20 and main burner air control valve 21, respectively. At the same time, the air is sent to oxidant pole 11B of fuel-cell 11 through air control valve 22, and the excess portion is sent to mixer 18 as energy for driving turbo compressor 19. After a portion of the air sent to oxidant pole 11B is consumed as it reacts with the hydrogen of aforementioned fuel pole 11A, it is exhausted along with the moisture generated in oxidant pole 11B. After a portion of the steam in the air exhaust gas is condensed by air exhaust gas steam separator 25 in the same manner as that with the fuel exhaust gas, said air exhaust gas merges with high-temperature exhaust gas 17 from aforementioned fuel reformer 5.

As described above, fuel-cell 11 generates electric energy by means of a catalytic reaction between the hydrogen in fuel pole 11A and the oxygen in oxidant pole 11B in such a manner that oxidant pole 11B becomes a positive pole (anode), and fuel pole 11A becomes a negative pole (cathode) and supplies said electric energy to electric load 26 connected between said electrodes 11A and 11B. In such a case, the hydrogen and the oxygen supplied to electrodes 11A and 11B react with each other roughly in proportion to the value of a current absorbed by electric load 26

to create reaction-generated water, and said steam-containing non-reacted gas portions are exhausted from the exits of electrodes 11A and 11B.

On the other hand, recycle line (recycle line) 14 is branched out from the exit of fuel pole 11A, and a portion of the fuel exhaust gas is returned to the entrance line of fuel pole 11A through fuel pole recycle blower 15. Similarly, line (recycle line) 23 is branched out from the exit /3
of oxidant pole 11, and a portion of the air exhaust gas is returned to the entrance line of oxidant pole 11B through recycle blower 24. The recycle lines of theses poles are provided for the purpose of reusing the gas left non-reacted after the battery reaction by recycling it, resulting in an effective use of the fuel gas and the air.

However, the conventional recycle line configuration shown in Figure 4 had the following problem. For example, the recycle line on the oxidant pole side will be explained.
Because oxygen in the equivalent to the amount of the electric load supplied to electric load 26 is consumed at oxidant pole 11B, the oxygen concentration in the oxidant pole exhaust gas is lower than the oxygen concentration in the oxidant pole entering gas. Because a portion of the exhaust gas with said low oxygen concentration is returned to the oxidant pole entrance pipe through recycle line 23 during the recycling, the oxygen concentration in the oxidant pole entrance pipe after merging with the recycle line is lower than the oxygen concentration in the oxidant supplied from oxidant pole flow rate control valve 22. Accordingly, the oxidant supplied from air control valve 22 is reduced as much as possible so as to take a large amount of battery exhaust gas in recycle line 23. Thus, if an attempt is made to utilize the battery non-reacted gas, the oxygen concentration in the oxidant pole entrance pipe after merging with recycle line 23 may become very low.

Incidentally, in the case of the fuel-cell, because the amount of oxygen supplied to the reaction surfaces of the electrodes increases as the oxygen concentration in the oxidant increases, the battery voltage rises. To the contrary, while it is characteristic in that the battery voltage drops as the oxygen concentration decreases, the voltage drops too low to generate electric power stably when the oxygen concentration becomes lower than a certain value, depending on the amount of the electric load.

Thus, the amount of oxidant pole exhaust gas in recycle line 23 must be regulated so as to bring the oxygen concentration in the oxidant pole entrance gas into a range where the battery voltage can be stabilized in order for electric power to be generated.

However, with the conventional recycle line configuration, because recycle blower 24 driven at a constant rpm produces a constant outflow, the amount of the oxidant pole exit exhaust gas branched out from recycle line 23 ends up becoming constant regardless of the amount of the load of the battery.

In addition, it is also the case that in a certain region where the electric load is small, the voltage of each cell unit constituting the battery exceeds a certain value and becomes too high, resulting in a risk of deteriorating the activation of the catalysts held on the surfaces of the electrodes. Thus, it is necessary to restrain an increase in the battery voltage by lowering the oxygen concentration in the oxidant pole entrance gas to a certain value utilizing the aforementioned concentration characteristic of the battery.

As such, the flow rate of the gas in the recycle line needs to be regulated according to the load region of the battery. However, as described above, conventional recycle line 23 had a problem that the flow rate of the gas in recycle line 23 was fixed and could not be regulated. In this respect, because the flow rate of the gas in recycle line 14 is fixed conventionally regardless of the amount of the electric load as is evident in the configuration of recycle line 14 on the fuel pole side, a similar problem to that of the oxidant pole side is expected to take place.

Purpose of the invention

The present invention was made in the light of the aforementioned problems, and its purpose is to present a fuel-cell power generating system by which the recycling flow rate can be regulated according to the electric load while keeping the battery oxidant entrance air flow rate or the concentration of the oxygen or the hydrogen in the fuel pole fuel flow rate after merging with the recycle line within a certain range so as to keep the battery characteristic stable as a result in order to allow electric power to be generated, and that the electrode exhaust gas can be utilized efficiently.

Outline of the invention

The present invention is characterized in that in a fuel-cell power generating system configured with a fuel-cell stack in which multiple battery cells each configured by providing a pair of electrodes comprising a fuel pole and an oxidant pole on either side of an electrolyte layer are layered together, and DC power is extracted from between the aforementioned electrodes /4 utilizing an electrochemical reaction which takes place when a fuel is brought into contact with the aforementioned fuel pole and an oxidant, such as air, to the oxidant pole, a recycle line configured as such that a portion of the electrode exhaust gas exhausted through an electrode exhaust gas pipe of at least the fuel pole or the oxidant pole is branched out and recycled into an electrode entrance pipe, and a recycle blower and a flow rate detector for detecting the gas flow rate are provided on said recycle line, a three-way valve is provided on the spout side of the aforementioned recycle blower, wherein one of its exits is connected to a line leading to the entrance of an electrode, and another exit is configured so as to be connected to a line leading to the intake side of the recycle blower, and a controller having a function to compare a flow rate

signal from the aforementioned flow rate detector with a prescribed flow rate setting value signal is provided in order to regulate the valve opening levels of the aforementioned three-way valve according to the deviation found; whereby, the flow rate of the gas in the recycle line can be regulated according to the amount of electric load.

Application example of the invention

An application example of the present invention will be explained below using the figures. Figure 1 is a block diagram of a fuel-cell power generating system as an application example of the present invention. Although recycle lines for an oxidant pole and a fuel pole are both illustrated, the recycle line on the oxidant pole side will be exemplified in the main text given below. In addition, the symbols in Figure 1 which have the same functions as those in Figure 4 are assigned with the same symbols, and their explanation will be omitted.

It is different from Figure 4 in that three-way valve 27B, flowmeter 28B, and line 29B (will be referred to as mini flow line, hereinafter) which returns to recycle blower 24 from three-way valve 27B are added on the exit side of recycle line 24. In addition, controller circuit 33B configured with converter 30B, adder 31B, and regulator part 32B is newly provided. The function of three-way valve 27B will be explained using Figure 2. A gas emitted at the flow rate of F_A from recycle blower 24 enters to side A of three-way valve 27B, a gas flows out from side B at the flow rate of F_B, and a gas flows out from side C at the flow rate equivalent to the difference between flow rate F_A of the gas emitted from recycle blower 24 and flow rate F_A of the gas emitted from recycle blower 24, goes through mini flow line 29B, and is returned to recycle line 23 on the intake side of recycle blower 24. In addition, three-way valve 27B has such a function that when the level of opening equivalent to gas flow rate F_B needed by side B is specified, the level of opening at side C is determined to become $F_C = F_A - F_B$.

On the other hand, in Figure 1, flow detector 28B is used to detect the flow rate of the oxidant pole exhaust gas in the recycle line linked to the oxidant pole entrance pipe from the three-way valve. In addition, controller circuit 33B has the following function. For example, upon receiving an electric load setting value signal or a measuring signal, converter 30B converts the electric load value signal into a flow rate signal according to the relationship between a prescribed electric load and the flow rate of the oxidant pole exit exhaust gas recycled. Said flow rate signal and the actual flow rate signal detected by flow detector 28B are computed by adder 31B in order to obtain a flow rate deviation. Then, upon receiving said flow rate deviation, regulator part 32B outputs a opening level signal corresponding to said flow rate deviation and gives it to the three-way valve.

With the aforementioned configuration in Figure 1, the present invention functions in the following manner. During the operation of the present fuel-cell power generating system, oxygen

concentration in the gas in the oxidant pole entrance pipe changes when the electric load changes, and the battery voltage changes. Upon receiving the electric load amount setting value signal or the measuring signal, converter 30B converts the electric load amount signal into a flow rate signal according to a prescribed function used to decide the relationship between the recycle flow rate and the amount of the electric load so as to keep the battery voltage characteristic in a safe range. The deviation between said flow rate signal and the actual flow rate signal from flow rate detector 28B is computed by adder 31B and converted into an opening level signal by regulator part 32B in order to specify the opening level at side B of three-way valve 27B shown in Figure 2. As a result, flow rate F_B for recycling can be regulated. As a result, the oxygen concentration of the gas in the oxidant pole entrance pipe can be kept within a fixed range, and the battery can generate power stably. In addition, as shown in Figure 2, excessive portion F_C of flow rate F_A emitted from blower 24 exits from side C of three-way valve 27B, goes through mini flow line 29B, and is returned to the recycle line on the entrance side of blower 24. /5

Said function can be used to regulate the flow rate of the gas to be recycled according to the amount of the electric load so as to regulate the flow rate of the gas recycled [sic; redundant] so as to regulate the concentration of the oxygen or the hydrogen flowing in the battery electrode entrance pipe in order for the battery to generate electric power stably. As a result, the electrode exhaust gas can be maximally utilized.

Although the recycle line on the oxidant pole side was exemplified in the explanation given above using Figure 1, the gist of the present invention can be applied perfectly well to the recycle line on the fuel pole side also.

Another application example of the invention

Figure 3 is a block diagram of a fuel-cell power generating system as an application example in accordance with the present invention. In the figure, the differences from Figure 1 are that regulator valves 37B and 38B are provided respectively on mini flow line 29B and recycle line 23 linked to the oxidant pole entrance pipe after branching out from mini flow line 29B, and that a controller circuit in which the deviation between a flow rate signal from flow rate detector 28B and outflow rate signal 34B determined based on the characteristic of the recycle blower is computed by adder 35B, said deviation signal is converted into an opening level signal, and the opening level signal is output to regulator valve 38B is added. As a result, the present invention functions in the following manner.

For example, upon receiving an electric load amount setting signal or a measuring signal, converter 30B converts said electric load amount into a flow rate signal according to a prescribed function and computes said flow rate signal and the actual flow rate signal from flow rate detector 28B using adder 31B in order to obtain a flow rate deviation signal. Said flow rate deviation is

converted into an opening level signal by regulator part 32B, said opening level signal is given to regulator valve 37B so as to regulate the level of opening in order to achieve a flow rate which matches the flow rate which has been set.

On the other hand, the difference between the outflow rate of recycle blower 24 and the flow rate of the gas flowing through regulator valve 37B needs to be regulated by regulator valve 38B in order to return [the gas] to recycle line 23 on the entrance side of recycle blower 24 through mini flow line 29B. Said regulator valve 38B is regulated in the following manner. First, the deviation between an actual flow rate signal from flow rate detector 28B and flow rate value signal 34B of recycle blower 24 already obtained is computed by adder 35B. Then, said flow rate deviation is converted into an opening level signal corresponding to the deviation by regulator part 36B and output to regulator valve 38B to regulate the opening level of regulator valve 38B. As described above, of the blower outflow rate, the excessive gas which was not returned to the oxidant pole entrance pipe can be returned to recycle line 23 on the entrance side of recycle blower 24.

When the configuration shown in Figure 3 is adopted, like the application example explained using Figure 1, the flow rate of the gas recycled to the oxidant pole entrance pipe can be regulated, and the same effect can be achieved.

In addition, recycling on the fuel pole side is exactly the same as the recycling on the oxidant pole side.

Effect of the invention

Because the present invention is configured in the manner explained above, the invention can achieve the following effect. That is, because the concentration of the oxygen or hydrogen in the gas flowing in the electrode entrance pipe can be kept in a certain range by regulating the recycling flow rate according to the electric load of the battery, the battery characteristic can be well maintained for stable generation of electric power, so that a fuel-cell power generating system in which non-reacted gas in the battery is utilized to the maximum through recycling can be presented.

Brief description of the figures

Figure 1 is a block diagram of the piping of a fuel-cell power generating system as an application example of the present invention. Figure 2 are diagrams for explaining the application example shown in Figure 1. Figure 3 is a block diagram of the piping of a fuel-cell power generating system as another application example of the present invention. Figure 4 is a block diagram of the major piping of a conventional fuel-cell power generating system for illustrating its configuration.

1	Raw fuel
2	Steam feeder
3	Raw fuel control valve
4	Steam control valve
5	Fuel reformer
6	Reformed catalyst tube
7	Transformer
8	Steam separator
9	Auxiliary burner
10	Fuel control valve for above
11	Fuel-cell
11A	Fuel pole
11B	Oxidant pole
12	Reformer fuel control valve 12
13	Main burner
14	Recycle line
15	Recycle blower
16	Steam separator
17	High-temperature exhaust gas
18	Mixer
19	Turbo compressor
19A	Turbine
19B	Compressor
20, 21, 22	Air control valve
23	Recycle line
24	Recycle blower
25	Steam separator
26	Electric load
27A, B	Three-way valve
29A, B	Mini flow line
30A, B	Converter
31A, B	Adder
32A, B	Regulator part
33A, B	Controller circuit

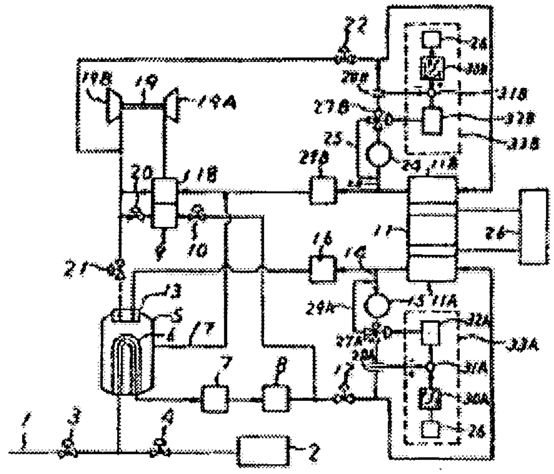

Figure 1

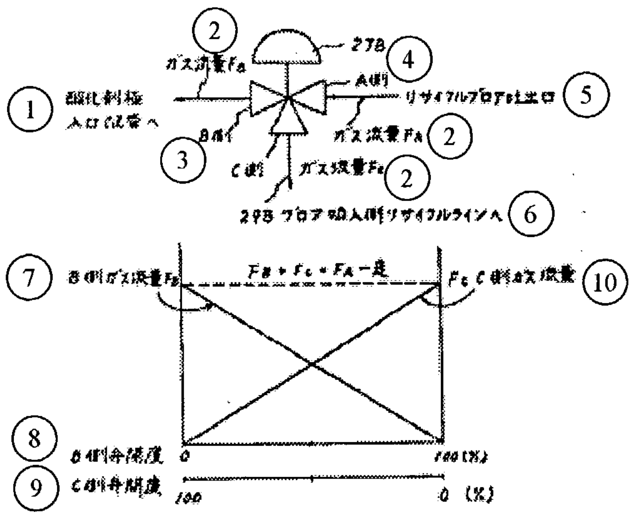

Figure 2

Keys:
1 To oxidant pole entrance pipe
2 Gas flow rate
3 Side B
4 Side A
5 Recycle blower spout
6 To recycle line on blower entrance side
7 Gas flow rate on side B
8 Valve opening level on side B
9 Valve opening level on side C
10 Gas flow rate on side C

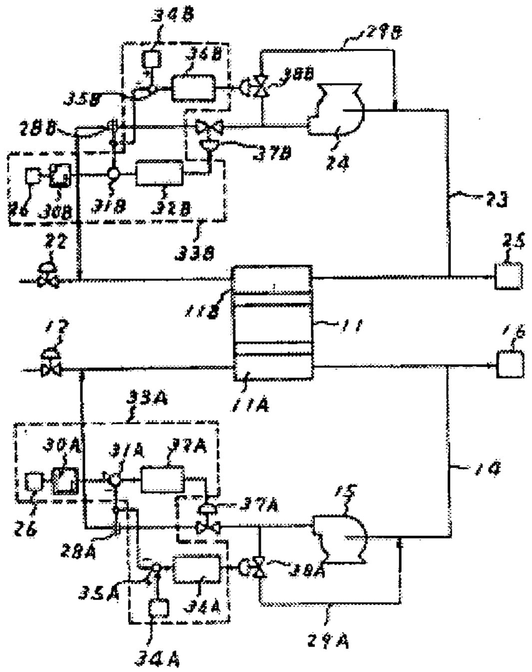

Figure 3

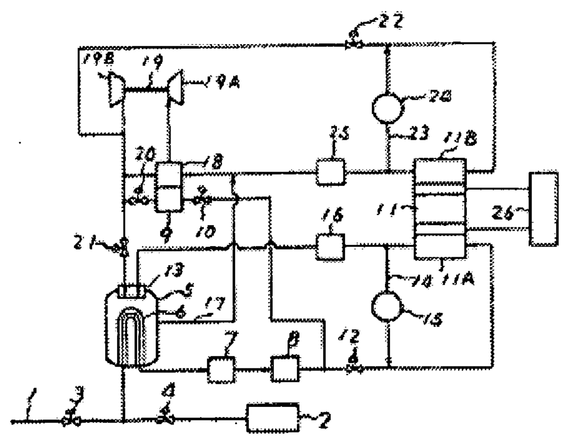

Figure 4